

A NEW SPECIES OF *SYNEMON* DOUBLEDAY (LEPIDOPTERA: CASTNIIDAE) FROM WESTERN AUSTRALIA

ANDREW A. E. WILLIAMS¹ and MATTHEW R. WILLIAMS²

¹*Department of Parks and Wildlife, WA Wildlife Research Centre, PO Box 51, Wanneroo, WA 6065*

²*Department of Parks and Wildlife, Keiran McNamara Conservation Science Centre, 17 Dick Perry Avenue, Kensington, WA 6151*

Abstract

The spring-flying sun-moth *Synemon edwardsi* sp. n. is described from southwestern Western Australia, where it occurs in small isolated colonies in the central and southern wheatbelt. Adults and the male and female genitalia are illustrated. The sun-moth's habitat, larval food plant and flight times are recorded. *Synemon edwardsi* sp. n. is compared with its Western Australian autumn-flying relatives *Synemon gratiosa* Westwood and *Synemon jcaria* R. Felder and with *Synemon laeta* Walker from eastern Australia.

Introduction

In 1948, A.M. Douglas collected the first three specimens of a small sun-moth, with orange and black hind wings, in bushland near the small wheatbelt town of Kukerin in southwestern Western Australia; the specimens were deposited in the Western Australian Museum. No further individuals were seen until Dr Terry Houston obtained a female at Charles Gardner Nature Reserve, 15 km south of Tammin, in 1996. These specimens were subsequently examined by E.D. Edwards, who considered them to be an undescribed species related to *Synemon gratiosa* Westwood and *Synemon jcaria* R. Felder. Genetic analysis has since confirmed that it is a distinct species (Williams *et al.* 2012).

The descriptions of Lepidoptera species published in the mid to late nineteenth Century were often limited to a single paragraph written in Latin, with hand drawn illustrations showing the insect's wing pattern and wing venation. This was the case for the three Castniidae species related to the new species, namely *S. laeta* Walker, *S. jcaria* and *S. gratiosa* (Westwood 1879). Even though these early descriptions are minimal, they offer some help in differentiating the species.

In 2010, surveys were undertaken by the Western Australian Department of Environment and Conservation (now Department of Parks and Wildlife) to determine the distribution and conservation status of the Graceful Sun-moth, *S. gratiosa* (Bishop *et al.* 2010a, b, Gamblin *et al.* 2011, Williams 2012, Williams *et al.* 2012). In conjunction with the Graceful Sun-moth surveys, the distribution of another closely related inland species, *Synemon jcaria*, was also examined. While conducting inland habitat surveys, the undescribed 'Kukerin Sun-moth' was found at several new localities in the Western Australian wheatbelt (Williams and Williams 2013b).

Institutional and private collections in which specimens are located are abbreviated as follows: AKC – Axel Kallies collection, Melbourne; ANIC – CSIRO Australian National Insect Collection, Canberra; WAM – Western Australian Museum, Perth; DPaW – Department of Parks and Wildlife.

***Synemon edwardsi* sp. n.**

(Figs 1-10)

Types. Holotype ♂, WESTERN AUSTRALIA: DPaW Database No. C 2011, labelled 'Kukerin Bushland, 21.xi.2011, open mallee woodland, sparse shrubs & sedges, 33°10'36.5"S 118°04'20.9"E, A.A.E. Williams, Reg. No. E89245' (in WAM). *Paratypes*: 99 ♂♂, 36 ♀♀: 1 ♀, DPaW Database No. C 2856, North Tarin Rock Nature Reserve, 8.xi.2012, tammar heath, sedges and *Chamaexeros fimbriata*, 32°58'52.6"S 118°16'01.5"E, A.A.E. Williams, Reg. No. E89250 (in WAM); 1 ♂, [label data 48:2950 refers to WAM Specimen Register entry on 24. xi.1948], Kukerin, A.M. Douglas, collection date not recorded (in ANIC on loan from WAM); 1 ♀, Charles Gardner Nat. Res. 15 km S. of Tammin, 21.xi.1996, T.F. Houston 919.6 (in ANIC on loan from WAM); 10 ♂♂, 5 ♀♀, Charles Gardner Nature Reserve, 5.xi.2010, 31°47'27.1"S 117°27'51.4"E, tammar shrubland over sparse low shrubs and sedges, A.A.E. Williams (1 ♂, 1 ♀ in ANIC, 1 ♀ in AKC, remainder in WAM); 2 ♂♂, 2 ♀♀, Charles Gardner Nature Reserve, 11.xi.2010, 31°47'27.1"S 117°27'51.4"E, tammar shrubland over sparse low shrubs and sedges, A.A.E. Williams (in WAM); 1 ♂, 1 ♀, Charles Gardner Nature Reserve, 11.xi.2011, 31°47'25.5"S 117°28'00.7"E, open tammar heath over sparse low shrub sedges, A.A.E. Williams (in WAM); 2 ♂♂, 1 ♀, Charles Gardner Nature Reserve, 12.xi.2011, 31°47'25.5"S 117°28'00.7"E, open tammar heath over sparse low shrub sedges, A.A.E. Williams (in WAM); 1 ♂, 2 ♀♀, Charles Gardner Nature Reserve, 10.xi.2012, 31°47'25.5"S 117°28'00.7"E, open tammar heath over sparse low shrub sedges, A.A.E. Williams (in WAM); 5 ♂♂, 6 ♀♀, Charles Gardner Nature Reserve, 12.xi.2013, 31°47'26.0"S 117°27'51.0"E, *Allocasuarina campestris* over *Chamaexeros fimbriata*, E.D. Edwards and M.R. Williams (in ANIC); 3 ♂♂, Corrigin Bushland Go-cart Track, 8.xi.2010, 32°21'10.6"S 117°51'38.3"E, mallee tammar shrubland over open heath and sedges, A.A.E. Williams (in WAM); 3 ♂♂, Corrigin Bushland Go-cart Track, 8.xi.2010, 32°21'08.1"S 117°51'51.1"E, open *Allocasuarina*, sparse low shrubs and sedges, A.A.E. Williams (2 in WAM, 1 in ANIC); 1 ♂, 1 ♀, Corrigin Bushland Wildflower Trail, 1.xi.2010, 32°20'18.7"S 117°49'55.6"E, tammar shrubland open low shrubs and sedges, A.A.E. Williams (1 ♂ in WAM, 1 ♀ in ANIC); 2 ♂♂, 1 ♀, Corrigin Bushland Wildflower Trail, 1.xi.2010, 32°20'19.8"S 117°49'57.2"E, tammar shrubland open low shrubs and sedges, A.A.E. Williams (in WAM); 1 ♂, Corrigin Bushland Wildflower Trail, 1.xi.2010, 32°20'20.3"S 117°49'54.7"E, tammar shrubland male on gravel road, A.A.E. Williams (in WAM); 1 ♀, Corrigin Bushland Wildflower Trail, 1.xi.2010, 32°20'18.7"S 117°49'55.6"E, tammar shrubland open low shrubs and sedges, A.A.E. Williams (in WAM); 1 ♂, 1 ♀, Corrigin Bushland, 20.xi.2011, 32°20'18.7"S 117°49'55.5"E, tammar shrubland and open low shrubs and sedges, A.A.E. Williams (in WAM); 2 ♂♂, 1 ♀, Corrigin Bushland, 13.xi.2012, 32°20'23.5"S 117°49'46.2"E, tammar shrubland and open low shrubs and sedges, A.A.E. Williams (in WAM); 4 ♂♂, Corrigin Bushland, 13.xi.2012, 32°20'18.7"S 117°49'55.6"E, tammar shrubland: flying along gravel track, A.A.E. Williams (in WAM); 1 ♀, Frank Hann

National Park, 22.xi.2011, 33°04'48.3"S 120°01'36.7"E, near *C. fimbriata* sedge on western park boundary, A.A.E. Williams (in WAM); 1 ♂, Kukerin Bushland, 1.xi.2010, 33°10'26.6"S 118°04'39.7"E, open mallee and tammar, small shrubs and sedges, A.A.E. Williams (in WAM); 1 ♀, Kukerin Bushland, 21.xi.2011, 33°10'36.5"S 118°04'20.9"E, open mallee woodland sparse shrubs and sedges, A.A.E. Williams (in WAM); 3 ♂♂, Kukerin Bushland, 8.xi.2012, 33°10'35.4"S 118°04'17.4"E, open mallee / shrubland, *Chamaexeros fimbriata*, A.A.E. Williams (in WAM); 7 ♂♂, Kulin Bushland, Macrocarpa Drive Trail, 1.xi.2010, 32°39'47.8"S 118°08'27.3"E, mallee / *Allocasuarina* over low shrubs and sedges, A.A.E. Williams (in WAM); 2 ♂♂, Kulin Bushland, Macrocarpa Drive Trail, 8.xi.2010, 32°39'49.4"S 118°08'28.6"E, mallee / *Allocasuarina* over low shrubs sedges, A.A.E. Williams (1 in WAM, 1 in ANIC); 2 ♂♂, 1 ♀, Kulin Bushland, Macrocarpa Drive Trail, 8.xi.2010, 32°39'47.8"S 118°08'27.3"E, mallee and *Allocasuarina* over low shrubs and sedges, A.A.E. Williams (in WAM); 2 ♂♂, Kulin Bushland, Macrocarpa Drive Trail, 8.xi.2010, 32°39'56.0"S 118°08'32.5"E, mallee and *Allocasuarina* over low shrubs and sedges, A.A.E. Williams (in WAM); 3 ♂♂, Kulin Bushland, Macrocarpa Drive Trail, 20.xi.2011, 32°39'49.8"S 118°08'30.2"E, mallee and *Allocasuarina* mixed shrubs and sedges, A.A.E. Williams (in WAM); 2 ♂♂, 1 ♀, Kulin Bushland, Macrocarpa Drive Trail, 20.xi.2011, 32°39'52.6"S 118°08'34.4"E, *Euc macrocarpa* / tammar shrubs and sparse sedges, A.A.E. Williams (in WAM); 1 ♂, Kulin Bushland, Macrocarpa Drive Trail, 23.xi.2011, 32°39'49.8"S 118°08'30.2"E, mallee and *Allocasuarina* mixed shrubs and sedges, A.A.E. Williams (in WAM); 1 ♂, 3 ♀♀, Kulin Bushland, Macrocarpa Drive Trail, 23.xi.2011, 32°39'52.6"S 118°08'34.4"E, *Euc macrocarpa* / tammar shrubs and sparse sedges, A.A.E. Williams (in WAM); 3 ♂♂, Kulin Bushland, Macrocarpa Drive Trail, 7.xi.2012, 32°39'49.8"S 118°08'30.2"E, mallee and *Allocasuarina* mixed shrubs and sedges, A.A.E. Williams (in WAM); 6 ♂♂, 1 ♀, Kunjin Bushland, 12 km WSW of Corrigin, 7.xi.2012, 32°20'56.9"S 117°46'15.0"E, mallee, tammar, *Melaleuca* over *Chamaexeros fimbriata*, A.A.E. Williams (in WAM, one aberrant male, cream hind wings); 1 ♂, Kunjin Bushland, 12 km WSW of Corrigin, 13.xi.2012, 32°21'06.0"S 117°46'12.8"E, mallee, tammar, *Melaleuca* over *Chamaexeros fimbriata*, A.A.E. Williams (in WAM); 4 ♂♂, 2 ♀♀, Kunjin Bushland, 12 km WSW of Corrigin, 13.xi.2012, 32°21'06.0"S 117°46'12.8"E, mallee, tammar, *Melaleuca* over *Chamaexeros fimbriata*, A.A.E. Williams (3 ♂♂, 2 ♀♀, in WAM, 1 ♂ in AKC); 1 ♂, North Lomos Road, 25 km west of Corrigin, 13.xi.2012, 32°21'26.2"S 117°36'37.2"E, tammar shrubland over *Chamaexeros fimbriata*, A.A.E. Williams (in WAM); 14 ♂♂, 2 ♀♀, North Tarin Rock Nature Reserve, 8.xi.2012, 32°58'52.6"S 118°16'01.5"E, tammar heath, sedges and *Chamaexeros fimbriata*, A.A.E. Williams (in WAM); 1 ♂, Overhue Nature Reserve, 7.xi.2012, 32°22'18.8"S 117°34'50.9"E, tammar shrubland over *Chamaexeros fimbriata*, A.A.E. Williams (in WAM); 5 ♂♂, Overhue Nature Reserve, 13.xi.2012, 32°22'23.4"S 117°34'58.3"E, tammar shrubland over *Chamaexeros fimbriata*, A.A.E. Williams (in WAM); 1 ♂, Tarin Rock Nature Reserve, 8.xi.2012, 33°06'26.5"S 118°12'25.5"E, open mallee heath, sedges, *Chamaexeros fimbriata*, A.A.E. Williams (in WAM).

Description. Holotype male (Figs 1-2). Head prominent; eyes large and rounded, eye surface very finely faceted, eye colour olive brown evenly spotted dull black in fresh specimen. Top of head densely scaled from between antennae and eyes to frons; each scale grey-brown with whitish

serrated ends or bifurcate tips. A line of long white vertical piliform hair-scales is located immediately behind the eyes and antennal bases. Antennae clubbed, antennal length 8.5 to 9 mm, extending less than half way along the forewing costa. Antennal shaft slender, evenly scaled black with seventeen evenly spaced narrow white segmental bands; white bands narrow above, more diffuse on underside of shaft. Antennal tip clubbed, club with short finely pointed tip. Scales on upperside of antennal club black, scales on underside of club predominantly white from base towards tip. Nudum narrow 8-10 flagellomeres. Labial palps densely covered in white scales that partially obscure a very short rudimentary proboscis; proboscis length <2.0 mm. Descaled labial palp reveals a bulbous basal segment and a long tapered mid segment attached at right angles and pointing anteriorly; the apical segment is small and short. [Proboscis and labial palps preserved in alcohol vial V518 – ex specimen # C 1091]. Thorax large, central portion of mesothorax dark grey, almost bare, but with some flattened scales and short white scale hairs. Prothorax and dorsolateral region of mesothorax above wing bases densely covered with a crescent-shaped shield of slightly raised overlapping scales, each scale grey-brown tipped whitish grey. A cluster of semi-erect dorsolateral elongate blackish-grey scales is located just above the base of the forewing. [These erect scales form the settled posture ‘shoulder tufts’ so characteristic of this sun-moth species group (Williams and Williams 2013a)]. Metathorax scales at junction with the abdomen are overlain with tufted long brown hairs emanating from the pleuron immediately behind the hindwing bases. Sternum covered with long whitish scales and hairs. Legs with white scales; tarsi on each leg with numerous short and acute posteriorly facing spines. Epiphysis short, with rounded tip, covered in short spines not nearly reaching the end of the foretibia. Abdomen above orange-brown covered in small round scales; anal tuft conspicuous, composed of narrow elongate orange-brown scales tipped whitish. Underside of abdomen grey-brown, banded with whitish scales at abdominal segment joints. Forewing: moderately slender, base to apex 14.5 mm, costa almost straight, slightly curved inwards near tip, apex pointed. Termen gently curved outwards, dorsum initially straight, angled inwards at midpoint to wing base attachment; upper surface entirely covered with slightly elongate serrated edged scales. Venation with accessory cell formed by anastomosis of the stem of R4+5 and R3 (Fig. 5). Upperside ground colour grey, paler in central subterminal to median area between two parallel indistinct broken black lines. The inner line of indistinct black markings runs from above the angled dorsum and culminates in three elongate postmedian black markings along M_1 , M_2 and M_3 near the costa. The outer line of indistinct black subterminal spots runs parallel to the termen. The forewing termen is narrowly edged grey-brown, with fringing scales whitish grey, tipped grey-brown. Hindwing: comparatively small and rounded; upper surface covered with small rounded scales, scale edges smooth, occasionally minutely

serrated. Hindwing upperside ground colour black, with broad deep bright orange postmedian band from 1A+2A to M_1 . Large deep bright orange discal patch located between CuA_1 and M_1 . Orange hindwing patches separated by an irregular but unbroken black crossband. Outer border black, termen fringe scales whitish grey tipped grey-brown except for small patch of white fringe scales towards apex. Underside of wings: forewing scales variable, both rounded and serrated; ground colour brownish grey merging to pale grey in subternal-dorsum area; prominent black subapical spot from which three smaller elongate white markings extend towards apex; subcostal area from wing base to subterminal line and median area dull orange, enclosing two almost confluent median-subcostal black spots. Hindwing underside scales usually serrated; ground colour black, apex grey; underside orange markings similar to above but extending to the basal area and inner dorsum alongside the abdomen; lower subbasal area and inner margin above dorsum overlain with long golden hair-scales arising from hindwing base. Frenulum long, pointed, dark brown (Fig. 6).



Figs 1-4. *Synemon edwardsi* sp. n.: (1-2) male upper and undersides, Kukerin Bushland, C 2011 (WAM); (3-4) female upper and undersides, North Tarin Rock Nature Reserve, C 2856 (WAM).

Female (Figs 3-4) similar to male but usually larger. Forewing broad and rounded, hind wing also rounded and proportionately larger than that of the male. Forewing upperside pattern similar to male but black markings often more distinct (Fig. 3). Hindwing upperside pattern more pronounced, the deep bright orange postmedian band extending into the inner dorsum margin alongside the abdomen (Fig. 3). This postmedian band is separated more clearly from the deep orange discal patch by a broad black crossband that joins the heavy black outer border. The female underside resembles the male, but the deep orange colouration is brighter and far more extensive.

Variation. There is considerable variation in the black markings on the upperside of the forewing in this species. In some individuals the markings are indistinct; in others the inner line markings may be almost confluent, forming a more distinct line. The outer line of spots parallel to the termen may also be bold and more pronounced, especially in females. One aberrant male from Kunjin Bushland, west-south-west of Corrigin, has cream rather than deep bright orange hindwing colouration. Male wingspan varies from 26-32 mm, female wingspan from 30-35 mm.

Male genitalia (Figs 7-9). Uncus short, broadly rounded with a few short setae; gnathos arms broad flat plates fused below; anal tube well sclerotised; tegumen broad, expanding to very broad where it joins the vinculum; vinculum sharply angled and poorly sclerotised above angle; saccus with broadly bifurcated arms; juxta well developed, bent sharply backwards to a point; valva compact, almost quadrate with prominent upturned spine at tip with numerous short setae and costa with stout setae; aedeagus moderately long, well sclerotised, broad and broadening anteriorly with phallobase sharply recurved, with flattened tip; ductus ejaculatorius much longer than aedeagus, with numerous coils.

Female genitalia (Fig. 10). Papillae anales short-pointed, sclerotised; ovipositor long, fairly narrow, sclerotised, with stout lateral hairs towards tip, numerous fine setae near base; apophyses long, heavily sclerotised; sinus vaginalis with sclerotised thickening; ostium bursae at posterior edge of sternum 7; ductus bursae long, narrow, tightly coiled; corpus bursae spherical without signum.

Etymology. This species is named in honour of E.D. (Ted) Edwards, a world authority on the Australian Castniidae, in recognition of his significant contribution to our present knowledge of the Australian sun-moth fauna.

Proposed English name. Splendid Sun-moth.

Larval food plant. The larval food plant is *Chamaexeros fimbriata* (F. Muell.) Benth. (Asparagaceae), a species very closely related to the matt-rush genus *Lomandra* (Asparagaceae), which is utilised by members of the same species group, *S. gratiosa*, *S. jcaria* and *S. laeta* (see Table 1).



Figs 5-6. *Synemon edwardsi* sp. n., male wing venation, Corrigin (Slide M-18641 (ANIC)): (5) forewing; (6) hind wing and frenulum.



Figs 7-10. *Synemon edwardsi* sp. n.: (7) male genitalia showing aedeagus, Charles Gardner Nat. Res. (Slide M-13638 (ANIC)); (8) male genitalia, aedeagus removed, right valva removed and placed on left of photo, remainder viewed from right side, Charles Gardner Nat. Res. (Slide M-13638 (ANIC)); (9) male genitalia, cut laterally on right side, spread and flattened, Charles Gardner Nat. Res. (Slide M-13639 (ANIC)); (10) female genitalia, Charles Gardner Nat. Res. (Slide M18640 (ANIC)).

Table 1. Diagnostic features and flight times for *Synemon edwardsi*, *S. gratiosa*, *S. jcaria* and *S. laeta*.

SPECIES	AVERAGE WING SPAN	FOREWING UPPERSIDE	HINDWING UPPERSIDE	PROBOSCIS	FLIGHT PERIOD
<i>S. edwardsi</i>	♂ 30 mm ♀ 32 mm	Uniform grey above with two oblique parallel broken black lines	Deep bright orange with a broad black border, solid black central band	Very short rudimentary proboscis	November
<i>S. gratiosa</i>	♂ 24 mm ♀ 30 mm	Variably patterned above with cryptic grey, black and whitish forewing markings	Orange with blackish border, centre unmarked or with variable blackish markings, sometimes with a curved black crossband. Blackish subbasal spot usually absent.	Very short rudimentary proboscis	Feb - April
<i>S. jcaria</i>	♂ 32 mm ♀ 38 mm	Variably patterned above with cryptic grey, black and whitish forewing markings	Orange with blackish border, partial or complete curved black central band, blackish subbasal spot almost always present.	Very short rudimentary proboscis	Jan - March
<i>S. laeta</i>	♂ 35 mm ♀ 42 mm	Ground colour grey to grey-brown, with three black to blackish patches forming distinct partial bands across the forewing.	Orange with broad black border and solid black crossband. Distinct blackish spot at base of hindwing.	Short coiled but apparently functional proboscis	Oct - Mar

Note: *Synemon edwardsi* and *S. gratiosa* are Western Australian species; *S. jcaria* is found in eastern and Western Australia, while *S. laeta* occurs in eastern Australia.

No detailed life history information is available for *S. edwardsi* apart from the fact that mid stage and mature larvae were found in the rhizomes of *C. fimbriata* plants at Charles Gardner Nature Reserve in November 2010. This suggests the life cycle may take two or more years to complete.

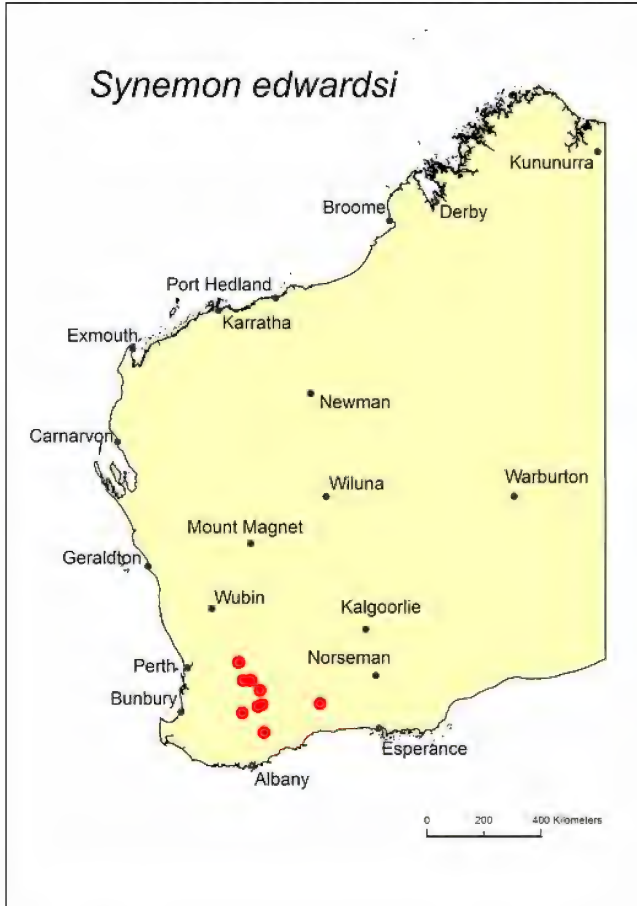


Fig. 11. Map of Western Australia showing distribution of *Synemon edwardsi*.

Distribution. The species is currently known from ten localities in the central and southern wheatbelt (Fig. 11): Charles Gardner Nature Reserve, Corrigin Bushland (now a Nature Reserve), Kunjin Bushland, native bushland alongside North Lomos Road near Corrigin, Kulin Bushland, Tarin Rock Nature Reserve, Overhue Nature Reserve, North Tarin Rock Nature Reserve,

Kukerin Bushland and the western boundary of Frank Hann National Park. The nine westernmost sites between Charles Gardner Nature Reserve and Kukerin Bushland are all isolated patches of native vegetation surrounded by cleared farmland. Only the outlying southeastern population on the western boundary of Frank Hann National Park adjoins a large expanse of uninterrupted native bushland.

Recognition. *Synemon edwardsi* can be readily distinguished from the two Western Australian species *S. jcaria* and *S. gratiosa*. These two autumn-flying sun-moths are morphologically similar, although most specimens of *S. jcaria* (Figs 16-19) are noticeably larger, more heavily marked and have more extensive underside white spotting than typical *S. gratiosa* (Figs 12-15) (Williams *et al.* in prep.).



Figs 12-15. *Synemon gratiosa*: (12) ♂ dorsal, Tamala Park, Perth; (13) ♂ ventral, Tamala Park, Perth; (14) ♀ dorsal, Yanchep, Perth; (15) ♀ ventral, Yanchep, Perth.



Figs 16-19. *Synemon jcaria*: (16) ♂ dorsal, Namelkatchem Nature Reserve; (17) ♂ ventral, Namelkatchem Nature Reserve; (18) ♀ dorsal, Drummond Nature Reserve, Toodyay; (19) ♀ ventral, Drummond Nature Reserve, Toodyay.

Synemon edwardsi can be readily identified in the field, being the only sun-moth of this size and colouration flying in the Western Australian wheatbelt in November (Figs 20-21).

Habitat. *Synemon edwardsi* is always found in close proximity to its larval food plant, *C. fimbriata* (Figs 22-23), which grows on sandy-clay soils. The sun-moths most frequently occur in open mallee / shrubland over open low heath with *C. fimbriata*, or within Tamma, *Allocasuarina campestris*, dominated shrubland where the ground cover is very open, low *Borya* sp. with scattered small sedges and tussocks of *C. fimbriata*. The presence of the larval food plant does not necessarily ensure that the sun-moth is present.

Behaviour and flight period. This small, fast-flying sun-moth occurs in isolated colonies where it invariably flies close to the ground. Males set up territories in areas of open ground and, where available, will frequently use low termite mounds as perching points (Fig. 23) (Williams and Williams 2013b). The flight period is very short, in some cases lasting only 2 weeks.



Figs 20-21. *Synemon edwardsi* sp. n.: (20) male basking posture, hindwing upperside exposed; (21) male settled closed-wing posture, showing elongate pointed forewing with diagnostic indistinct parallel broken black lines (photos by Andrew Williams).



Figs 22-23. (22) Typical habitat for *Synemon edwardsi* – note the large *Chamaexeros fimbriata* tussock plant to the left of the termite mound; (23) *Synemon edwardsi* larval food plant, *Chamaexeros fimbriata* (photos by Andrew Williams).

Adults fly in November, but the exact date of their emergence depends on annual weather conditions. In dry years the species appears in very early November but in cooler, wetter seasons does not fly until later in the month (Williams and Williams 2013b). The sun-moths are active in warm to hot sunny conditions and, like other species, will settle when cloud cover appears.

Conservation status and management implications. In view of predicted drying trends for the Western Australian wheatbelt, this sun-moth may be regarded as threatened in the northern parts of its range where it is restricted to a few small remnant patches of native vegetation (Williams and Williams 2013a). Only if the species is found in the more extensive moister southern native bushlands in and near Frank Hann National Park, where its larval food plant is known to occur, can its status be regarded as more secure.

Discussion

The original three *S. edwardsi* specimens were collected by Athol Douglas. Two of these have not been located; the third is in the Australian National Insect Collection in Canberra, on loan from the Western Australian Museum. The only information on the original specimen label is 48.2950. This refers to a 1948 acquisition entry in the WA Museum Register on 24th December 1948. The specimens were probably collected on a field trip in November 1948 and deposited in the WA Museum collection the following month (Brian Hanich, WAM Invertebrate Collection Manager, pers. comm.). Almost five decades later, Dr Terry Houston secured a female at Charles Gardner Nature Reserve on 21 November 1996. His field notebook records 'Flying at 3:30 pm in *Borya l* sedge area and perched on dead stem 40 cm high – castniid.' (T.F. Houston pers. comm.). Recent searches at Charles Gardner Nature Reserve ultimately resulted in the location of a population of *S. edwardsi* there and the identification of *C. fimbriata* (Fig. 23) as its larval food plant. The Department of Parks and Wildlife's Florabase website provided location data for other *C. fimbriata* sites where *S. edwardsi* might be expected to occur. Targeted surveys at these locations resulted in the ten confirmed *S. edwardsi* localities listed above.

Synemon edwardsi belongs to a group of four allied sun-moths, the other three being *S. gratiosa*, *S. jcaria* and *S. laeta*. This group is characterised by the presence of an accessory cell in the forewing and the Asparagaceae feeding habit of the larva. It shares the compact valva and the presence of sensory hairs near the base of the ovipositor with the *S. magnifica* group. *Synemon edwardsi*, *S. gratiosa* and *S. jcaria* all occur in southwestern Western Australia (Williams and Williams 2013b), while *S. laeta* is confined to eastern Queensland (CSIRO 2015) and northern New South Wales (Murphy 2015). The flight times of the three Western Australian species differ: *S. gratiosa* and its inland relative *S. jcaria* fly in late summer and autumn, while *S. edwardsi* flies in late spring (Williams and Williams 2013b,

Williams *et al.* in prep.). As the distribution of *S. jcaria* overlaps that of *S. edwardsi* and, in places their respective food plants grow together, it is possible that at some sites the two species coexist but remain temporally separated. It is interesting that both *S. gratiosa* and *S. jcaria* have reduced, barely functional mouthparts and fly at times when flowering plants are not generally available. *Synemon edwardsi* has similarly reduced mouthparts that appear inadequate for normal nectar intake but it flies at times when at least some plants are in flower. *Synemon laeta* from eastern Australia has a short apparently functional proboscis but, like its Western Australian counterparts, is not known to visit flowers (E.D. Edwards pers. comm.).

Genetic analysis has confirmed that *S. edwardsi* is a distinct species, its closest relatives being *S. gratiosa* and *S. jcaria* (Williams *et al.* 2012). The larval food plants for all four sun-moth species belong to the plant family Asparagaceae: *S. gratiosa*, *S. jcaria* and *S. laeta* all feed on *Lomandra* species (Edwards 1997, Edwards pers. comm., pers. obs.). The food plant for *S. edwardsi*, *Chamaexeros fimbriata*, is very closely related to *Lomandra*; indeed, it has been proposed that the genus *Chamaexeros* be included within *Lomandra* (Greg Keighery, Department of Parks and Wildlife, pers. comm.).

Acknowledgements

We are very grateful to Yu Ning Su, CSIRO Australian National Insect Collection, for the genitalia and wing venation slide illustrations, and Brian Hanich and Nik Tatarnc, Western Australian Museum, for the sun-moth photo illustrations. Ted Edwards provided guidance and helpful comments on the original draft manuscript.

References

- BISHOP, C., WILLIAMS, M., MITCHELL, D. and GAMBLIN, T. 2010a. *Survey guidelines for the graceful sun-moth (Synemon gratiosa) & site habitat assessments*. Department of Environment and Conservation, Kensington, WA; 20 pp.
- BISHOP, C., WILLIAMS, M., MITCHELL, D., WILLIAMS, A., FISSIOLI, J. and GAMBLIN, T. 2010b. *Conservation of the graceful sun-moth (Synemon gratiosa): findings from the 2010 graceful sun-moth surveys and habitat assessments across the Swan, South West and southern Midwest regions: interim report, August 2010*. Department of Environment and Conservation, Kensington, WA; 30 pp.
- CSIRO.2015. Atlas of Living Australia, Castniidae. Viewed 22 June 2015. <http://bie.ala.org.au/species/urn:lsid:biodiversity.org>
- EDWARDS, E.D. 1997. Moths in the sun. *ANIC News* 10: 7-8.
- FLORABASE (Western Australian Herbarium). 1998-. FloraBase-the Western Australian Flora. Department of Parks and Wildlife. <https://florabase.dpaw.wa.gov.au/>
- GAMBLIN, T., BISHOP, C., WILLIAMS, M. and WILLIAMS, A. 2011. Graceful sun-moth (*Synemon gratiosa*). Available at: <http://www.dpaw.wa.gov.au/about-us/science-and-research/publications-resources/111-sciences-division-information-sheets.41/2011.2p>.
- MURPHY, M.J. 2015. First records of the sun moth *Synemon laeta* Walker, 1854 (Lepidoptera: Castniidae) from New South Wales. *Victorian Naturalist* 132(2): 44-48.

WESTWOOD, J.O. 1879. A monograph of the lepidopterous Genus *Castmia* and some allied groups. *Transactions of the Linnean Society, Series 2, Zoology* **1**: 155-207, pls 28-33.

WILLIAMS, A. and WILLIAMS, M. 2013a. Sun-moth haven in the wheatbelt: Wyalkatchem Nature Reserve. *Landscape* **28**(4): 24-30.

WILLIAMS, A.A.E. and WILLIAMS, M.R. 2013b. Kukerin sun-moth, *Synemon* sp. Kukerin, rediscovered. Available at: <http://www.dpaw.wa.gov.au/about-us/science-and-research/publications-resources/111-science-division-information-sheets.67/2013,2p>.

WILLIAMS, A.A.E. and WILLIAMS, M.R. 2016. *Castmiidae Database (sorted by species / locality / date)*. Department of Parks and Wildlife, Science and Conservation Division, Kensington WA; p. 66.

WILLIAMS, M. 2012. "Graceful sun-moth – survey results". *Western Australian Insect Study Society Newsletter*. **April 2012**: 3-6.

WILLIAMS, M., BISHOP, C., MITCHELL, D., WILLIAMS A. and GAMBLIN, T. 2012. *Conservation of the graceful sun-moth (Synemon gratiosa): survey results from the Swan, South West and southern Midwest regions 2010-2012: summary report*. Department of Environment and Conservation, Kensington, WA; 16 pp.